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ED 392 600

Students' Language Proficiency Effects Upon Teachers' Assessment of Students' Mathematical Understanding

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Abstract

In current mathematics reform, assessment is integral to effective instruction. However, accurate assessment of over three million limited English proficient (LEP) students in today's schools is of great concern. How does students' language proficiency affect the accuracy of teachers' assessment of students' mathematical understanding? This research quantitatively and qualitatively examined teachers' assessment of students' mathematical understanding through analysis of teachers' prediction of students' performance on a fraction test, videotaped tutoring sessions with one LEP student and one non-LEP student, and subsequent individual interviews with teachers and students. Gutierrez' (1993) construct of instructional script provides theoretical background to address interaction between teachers and individual students. This research found that teachers' different instructional scripts created differential opportunities for teachers to assess students' mathematical understanding. Results indicate that teachers know less about LEP students' mathematical understanding than non-LEP students' understanding. Teachers need assistance in closing gaps between how they believe they teach and assess LEP students' understanding and reality.

Introduction

Mathematics reform inspired by Curriculum and Evaluation Standards for School Mathematics (NCTM, 1989) and other similar documents demand that students communicate their reasoning, write explanations of their process, and solve complex problems. Curriculum developed under Standards' guidelines is therefore increasingly language based. At the same time, these documents maintain that assessment is integral to effective instruction. How are the over three million limited English proficient (LEP) students in today's schools impacted by these reform efforts? Most importantly for this research, as teachers develop models of students' mathematical understanding in their minds based on their assessments, how much do they understand the difficulties that LEP students have?

A significant impact of language upon assessment may correspond with a significant impact upon teachers' effectiveness with LEP students. While studies have examined disparities in the standardized assessment of minority mathematics achievement due to language factors (i.e. Aiken, 1971; Cocking & Chipman, 1988; DeAvila & Duncan, 1981; Garcia, 1991) no known studies have focused upon the impact that language may have upon teachers' assessment of students' understanding in mathematics. This research therefore examines the question *"How does students' language proficiency affect the accuracy of teachers' assessment of students' mathematical understanding?"* In the following I present further rationale for the present study and the theoretical background that serves as a foundation for the research.

Assessment Integral to Instruction

Mathematical reform-minded documents prescribe that "Instructional activities should be based on information obtained from assessing students' mathematical understanding" (NCTM, 1991, p. 110). Accurate assessment of students' understanding is "a critical link in the educational process" and is essential to effective instruction (NCTM, 1993, p. 3). Knowing assessment's stated importance, if teachers inaccurately or incompletely assess students' understanding, then they will likely build incomplete models of students' understanding in their minds and make their instructional decisions upon faulty information, perhaps adversely affecting students' education.

The teacher effectiveness literature indicates that an important area of concern is instruction based on teachers' development of mental models. Studies describe effective teachers as consistently monitoring students' progress (Brophy and Good, 1986), understanding variations in ability and background of students (Shulman, 1987), and knowing whether their students could solve different problems (Carpenter, Fennema, Peterson, and Carey, 1988). Effective teachers use this knowledge to inform their instruction. Accordingly, the purpose of this research is to help teachers know about obstacles they may face in assessing LEP students' understanding so they can be more effective.

The Importance of Language Proficiency

Since *Brown v. Board of Education* in 1954, research documenting the disparity in effectiveness of education in the United States for non-white students has grown tremendously. Nevertheless, the dropout rate among Hispanic students currently stands at 40-50 percent in comparison to 14 percent for whites and 25 percent for blacks. In addition, a two to

four grade level achievement gap between Anglo and Hispanic students has been demonstrated (Garcia, 1991). However, in spite of its inclusive goals, implementation of Standards may adversely affect immigrant populations. Due to increased emphasis on communication of ideas and problem solving, new mathematics courses that are compatible with Standards *will demand a much greater command of language skills* than previously required for success. This places more burdens upon limited English speaking students in mathematics classes. However, emphasis on communication should not be decreased for LEP students to be "successful". Instead, communication should be encouraged and supported by ensuring teachers' accurate assessment of LEP students' mathematical understandings.

While numerous studies identify the lower achievement in mathematics of language minority students (Cocking & Chipman, 1988; Secada, 1992), only recently has research concentrated on the effects of language proficiency on mathematics achievement. Issues regarding LEP students are increasingly significant throughout the nation. The National Center for Education Statistics projects 3.4 million LEP students between the ages of 5 and 14 years by the year 2000 (Cuevas, 1984). A number of studies have identified evidence for a significant, positive correlation between math achievement and verbal ability (Aiken, 1971; Cocking & Chipman, 1988). Also, DeAvila and Duncan (1981) and Fernandez and Nielsen (1986) found a significant relationship between Hispanics' English proficiency and their mathematics achievement.

In this comparative analysis of LEP students to non-LEP students, I examine the accuracy of teachers' assessment of LEP students' understanding. The goal of this research is to help teachers become more

effective in their instruction, particularly with LEP students, by increasing teachers' awareness of issues and obstacles that they may face regarding the accurate assessment of students' mathematical understanding.

Theoretical Framework

The primary focus regarding the theoretical framework of this research is the interaction between teachers and students. I present the theoretical framework to examine this interaction under the overarching construct of instructional script (Gutierrez, 1993).

Instructional Script

Gutierrez' (1992, 1993) work on instructional script provides a structure from which to address teachers' interaction with students. Gutierrez found that instruction could be characterized by "particular social hierarchies, participation structures, discourse patterns, and knowledge exchange systems in which beliefs about the teaching and learning of literacy resided" (1993, p. 4). These sociocontextual features capture the important relationship between discourse, interaction and context that make up the construct of "script." This analytical scheme organizes instruction into three distinct instructional scripts: recitation, responsive, and responsive/collaborative. These scripts are distinguished on the basis of how the teacher determines the rules and rights of participation in interaction, whose knowledge is valued, and the amount of access students have to meaningful participation. The recitative script consists primarily of teacher control and transmitted knowledge. The responsive script occurs when students contribute more to the interaction while the teacher still maintains the majority of control. A responsive/collaborative

instructional script most closely resembles co-construction between teacher and student.

Teachers' use of differing instructional scripts may have a significant impact upon the amount of information concerning students' understanding that is available to the teacher. Particularly, the amount and quality of student participation may extend or lessen teachers' access to students' reasoning and therefore to their mathematical understanding. For example, teachers whose instructional script is recitation may be less likely to develop an accurate assessment of students' understanding because use of that script explores and incorporates less of students' understanding.

In the case of limited English proficient students these results may be heightened because of the additive affect that language has upon communication during the interaction. Due to language factors, teachers may vary in their use of instructional script with LEP students as opposed to non-LEP students, therefore providing teachers with differential amounts of information regarding LEP students' understanding as opposed to non-LEP students' understanding. In this research, I examine extended interaction between teachers and students using Gutierrez' model of teachers' instructional scripts and explore the possible association of the accuracy of teachers' assessment with teachers' instructional script.

Teachers' Mental Models

While the primary focus of instructional script is upon discourse patterns, a number of other factors contribute to the instructional context created as teachers use particular instructional scripts. One such factor is the mental model of students' understanding that teachers bring, use, and modify during interactions with students. Further, discourse that is used

during instruction and when teachers reflect about that instruction may indicate the type and depth of mental models of students' mathematical understanding that teachers develop. Two perspectives of the mental models that teachers generate are considered here, one focused on specific mathematical content understanding and the other on general student characteristics. In a stimulated recall interview process this research analyzes the evidence upon which teachers base their assessments and construct specific and/or general mental models of students' understanding.

If teachers develop specific mental models concerning mathematical concepts as they assess students' understanding, then they are able to modify their instruction to students' specific needs. Cognitively Guided Instruction studies (i.e. Carpenter, et al., 1992) have shown that teachers with these specific models of students' understanding are more effective in the classroom. For instance, given a model based on specific mathematical concepts, a teacher might be able to develop a problem that helps a student see the conflict between the incorrect mathematical idea that he or she holds and the true mathematical idea. One difficulty for teachers who try to develop specific mental models of students' mathematical understanding is that students may see a situation differently than how teachers may view the situation. Tasker (1980) and Dyson (1984), for example, show that considerable discrepancies may exist between teachers' assumptions about what pupils are thinking and what students attain from a learning experience. As teachers may lack complete information from the limited English language spoken by LEP students, these findings may be exacerbated in the case of LEP students.

On the other hand, teachers may use their mental models of students' general character as a basis for assessing students' mathematical understanding. Therefore, during instruction, they may only address the general character of the student rather than the specific mathematical concepts. For instance, if a teacher assesses that a student struggles with a mathematical idea then the teacher may instruct the student to "try harder" because they have a mental model of the student as "lazy". These issues concerning mental models are of particular interest in this research on assessment of LEP students. In comparison with non-LEP students, are teachers assessing the specific mathematical needs of LEP students or general characteristics? If teachers have an inaccurate or incomplete understanding of students' knowledge, then it follows that they may not be instructing them effectively.

Final Summary

In order to address the research question *"How does students' language proficiency affect the accuracy of teachers' assessment of students' mathematical understanding?"* this study examined not only the question of "how much accuracy?" but also the question "what factors influence accuracy of teachers' assessment?" Towards that goal, Gutierrez' construct of instructional script forms the theoretical foundation to analyze what teachers do, say, and think in interaction with students of mathematics. In all analyses of data, the main concern was the possible differential in accuracy of teachers' assessment of LEP students' versus non-LEP students' mathematical understanding. An essential goal of this research was to explore factors that may account for that differential.

Method

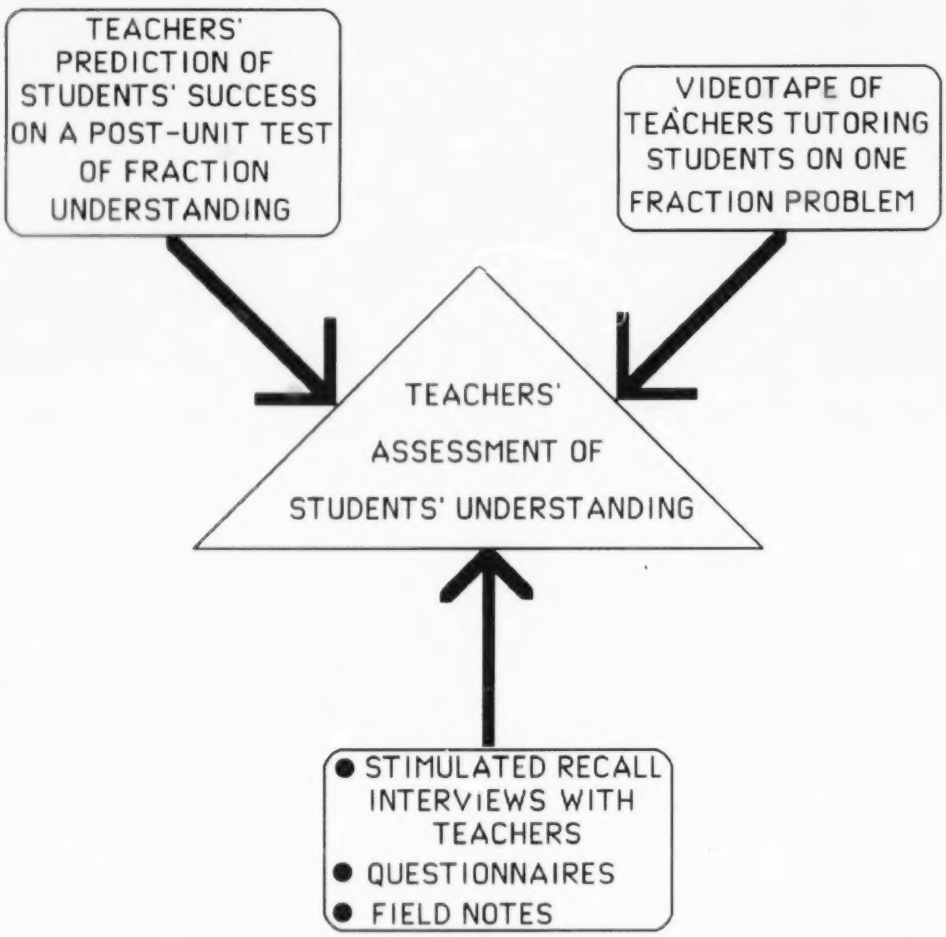
In order to study the research question I quantitatively and qualitatively examined teachers' assessment of students' mathematical understanding through triangulation of three sets of data: videotape of students and teachers interaction in a controlled tutoring situation; individual stimulated recall interviews with teachers; and teachers' prediction of students' success on a post-unit fractions test (Figure 1). While teachers' prediction of students' success importantly accessed a whole class perspective of teachers' assessment, the videotaped tutoring session was the heart of this research. A stimulated-recall interview followed the tutoring session to examine evidence teachers use for assessment, and students' understanding of the mathematical concepts involved in the tutoring problems. In analysis of each set of data, I explored possible differences in teachers' interaction and assessment of LEP and non-LEP students.

Data Source

Twenty-two fourth, fifth, or sixth grade teachers were selected who used the mathematics replacement unit *Seeing Fractions*, developed by Technical Educational Research Centers (TERC) and published by the California Department of Education. The teachers were from four districts in the general Los Angeles area and had been trained in sheltered English techniques for limited English proficient students. These teachers' classes had a minimum of 10 percent limited English proficient (LEP) students and 10 percent non-LEP students. Instruction in these classes was in English. Teachers had been teaching their present class for a minimum of three

months, so as to provide opportunity for teachers to become familiar with their students.

FIGURE 1
Summary Chart


TEACHERS' PREDICTION OF STUDENTS' SUCCESS ON A POST-UNIT TEST OF FRACTION UNDERSTANDING
VIDEOTAPE OF TEACHERS TUTORING STUDENTS ON ONE FRACTION PROBLEM
TEACHERS' ASSESSMENT OF STUDENTS' UNDERSTANDING
STIMULATED RECALL INTERVIEWS WITH TEACHERS
QUESTIONNAIRES
FIELD NOTES

Ten of the teachers were selected for the qualitative study involving the tutoring of two students on the basis that they all taught fifth grade. Two male students were selected from each of the teachers' classes for tutoring from a group of students who had gained parental permission and

who had comparable California Test of Basic Skills (CTBS) math scores. Male students were selected in order to control for gender differences that might exist. One of the students was classified by the district as Limited English Proficient (LEP). The other student was classified as fluent English speaking. Therefore, this procedure yielded 10 LEP student subjects and 10 non-LEP students for tutoring.

Procedure

Three sets of data were accumulated for each of ten teachers who tutored two students individually (one LEP and one non-LEP): data from the tutoring session, interviews, and teachers' prediction of students' performance on the post-test on fractions. In order to get a larger sample size for quantitative analysis, an additional twelve teachers predicted their students' performance on the post-test.

Tutoring Sessions.

The first set of data was collected from the tutoring sessions. Tutoring occurred before the third module of the *Seeing Fractions* unit because that module contains the problem solving strategies that were required for the tutoring problem. Teachers tutored the two students individually, outside of class time, while being videotaped on the problem: "Who got more pizza, a person in a group of three people sharing one pizza or a person in a group of eight people sharing three pizzas?" The directions for the teacher were to "help the student understand how to do these problems. You can use any materials that you would normally use." The order of instruction for LEP and non-LEP students with each teacher was alternated in order to counterbalance any learning effects. The videotaped tutoring sessions between teachers and students were

transcribed and then coded using a modified version of Gutierrez and Estrada's (1992) coding scheme.

Interviews.

The second set of data was developed in stimulated-recall interviews with teachers. Within one week of the tutoring the teachers were individually interviewed while they watched the videotape of the tutoring session. The interview provided an opportunity to obtain the teacher's rationale and evidence used in their generation of an assessment of a student's understanding. While watching the videotaped interaction, the teacher was asked to reflect on what she/he was thinking about the student's understanding. The interviews with teachers were transcribed and qualitatively analyzed with an emergent coding scheme. Particular attention was focused on teachers' assessment strategies as well as their assumptions of students' thinking in comparison to students' report of what they were thinking. Throughout the analysis, differences between interaction with LEP students versus fluent students were explored.

Teachers' prediction of students' performance.

The third set of data was collected from teachers' prediction of students' performance on a post-test of students' fractional understanding from the *Seeing Fractions* unit. At the conclusion of instruction on the third module, I administered the Whole Class Fractions Test to all the students in each of the twenty teachers' classes. While the students took the post-test, the teacher filled out a prediction form. On that form the teacher considered each student and made a prediction, for each problem of the test, whether the student would get the correct answer. These predictions were then compared with how well students actually performed. Each teacher was also given an information sheet that

explained my interpretations of answers to problems. This information ensured that teachers predicted students' performance on the same basis that the two judges would grade them. The two judges scored each students' test and their reliability was high. After making their predictions, I allowed teachers to view the tests completed by the student. I noted the teacher's reactions as they compared the actual students' performance to their predictions. The match between students' actual scores and the teacher's prediction produced an accuracy of assessment score. This score provided the basis of the quantitative analysis of the whole class level of instruction.

Results

Triangulation of analyses provides some possible answers to the research question *"How does language proficiency affect the accuracy of teachers' assessment of students' mathematical understanding?"* In this section I present the qualitative and quantitative results from examination of the videotaped tutoring sessions, interviews, and teachers' prediction.

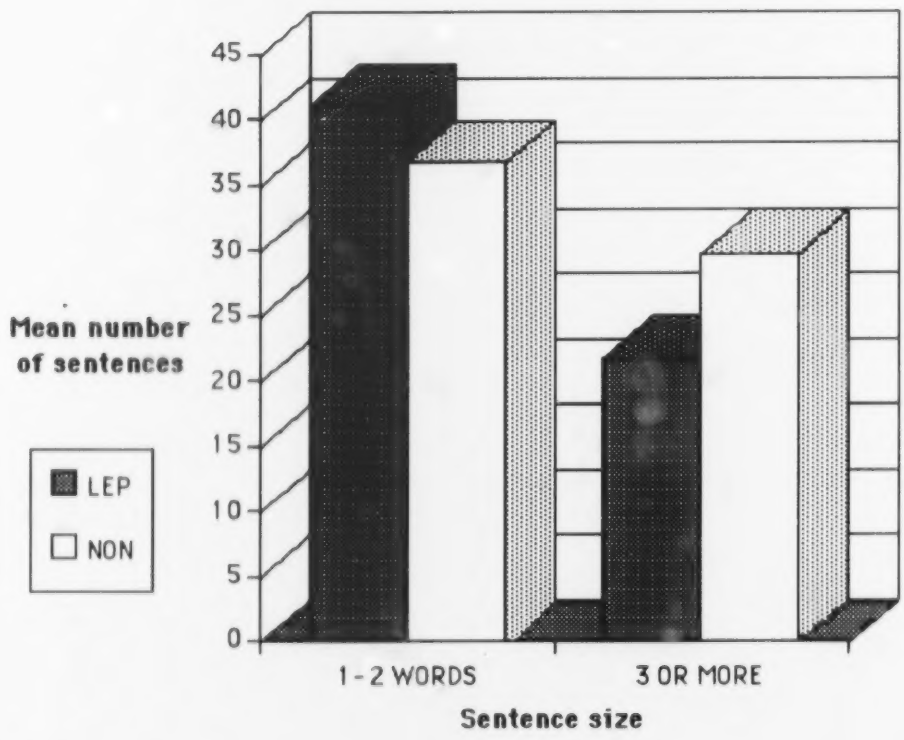
Tutoring Sessions

The tutoring sessions lasted an average of 17 minutes and 14 seconds with a range of 4:21 to 33:10 (SD = 7.46). Analysis of the sessions using the coding scheme revealed that most teachers used responsive instructional scripts. That is, while students participated in the tutoring session, teachers typically had control of the direction of the session, spoke almost four times (78.36%) as many words as students spoke, and asked 95.71% of the questions. As sixty percent of students' talk consisted of one to two word sentences, there was very little verbal information for

teachers to use for assessment purposes. In addition, more detailed analysis revealed inequitable patterns in LEP students' responses, use of manipulatives, and opportunity to answer teachers' questions.

FIGURE 2

Number of words spoken per sentence by students



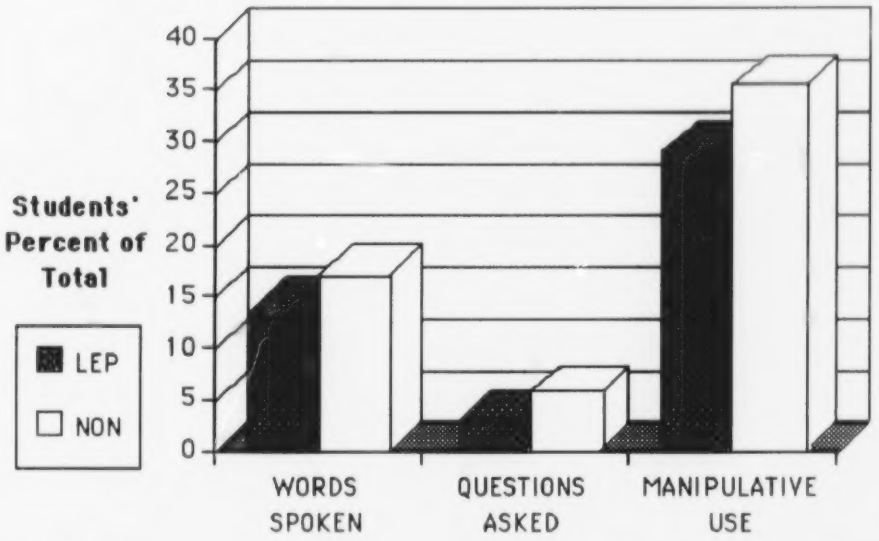
Students' response patterns.

While the difference in instructional scripts teachers used between LEP and non-LEP students was not significant t (9) = 1.69, ($p > .05$), some inequitable patterns emerged upon further analysis of subcategories of instructional script. For instance, Figure 2 demonstrates that LEP students spoke more one or two word sentences (although not significant, $t = 1.08$, p

> .05) and they spoke significantly less sentences three words or over than non-LEP students ($t = 1.99$, $p < .05$). LEP students therefore gave less elaborated verbalizations during tutoring than non-LEP students. This indicates not only limited availability of information about LEP students' understanding to the teacher, but also the type of information available to the teacher for assessment. Given that LEP students spoke more one or two word sentences, this implies that teachers focused primarily on "correct answers" rather than on students elaboration of their reasoning.

FIGURE 3

Tutoring Session Summary



Manipulative use.

I analyzed the three quantitative subcategories for instructional script (percent of total words spoken by the student, percent of total questions asked by the student, and the percent of total time the student used manipulatives) to determine if there were any significant differences between LEP students and non-LEP students. Figure 3 shows the summary

chart for that data. LEP students spoke a smaller percentage of the words in tutoring, asked fewer questions, and even used manipulatives less than non-LEP students. Two of the differences were not significant, $t(9) = 1.06$, ($p > .05$) for percent of words spoken by the student; $t(9) = 1.69$, ($p > .05$) for percent of questions asked by the student. However, Non-LEP students used manipulatives significantly more than LEP students $t(9) = 2.14$, ($p < .05$).

This finding is very surprising as one would expect teachers to try to compensate LEP students' language limitations by having them use manipulatives more. In fact, in the post-study questionnaire, the majority of teachers referred to "sheltering techniques" that they used with students that consisted primarily of increased use of manipulatives and "visuals". In addition, all teachers in the districts were trained in Specially Designed Academic Instruction in English (SDAIE), a strategy that encourages increased non-language based instruction, (such as manipulative use) for LEP students. In spite of this training, this study found that there is a significant gap between teachers' beliefs or intentions and teachers' actions. In the tutoring session non-LEP students actually used manipulatives more than LEP students.

One possible reason for this unexpected pattern with students' manipulative use is that LEP students may not have been as socialized in manipulative use as non-LEP students. LEP students likely have origins in different country's school systems and therefore didn't have access to instruction with manipulatives. Further, LEP students may not have had much access to instruction with manipulatives in mathematics within their present school system due to pull out programs for language development.

Another possible reason is that LEP students may have been socialized to be more passive in mathematics classrooms because of their struggles with the English language. During interviews, teachers in this study often referred to their LEP students as the "quiet" ones. This may indicate LEP students' reluctance (rather than character traits), to be more active during instruction due to limited English proficiency, socialization in the classroom environment, or some other reason. Limited use of manipulatives may therefore be a symptom of some underlying dynamics in the classroom environment for LEP students. These are merely hypotheses for this phenomenon which should be examined more closely in future research.

Teachers' unanswered questions.

Qualitative analysis of teachers' interaction with students in tutoring revealed distressing patterns in teachers' questioning practices. Teachers ask more "unanswered questions" of LEP students than non-LEP students. That is, teachers ask LEP students more questions in chains than non-LEP students without expecting or waiting for answers. In this pattern of unanswered questions, teachers do not allow any wait time (less than two seconds) before asking the next question. For example, a teacher is tutoring a student on how to partition one "pizza" so as to share the pieces equitably between three people:

Example 1: Unanswered questions with LEP student

T: Okay, you want to divide it into six? [no wait time/no response] Okay. How could we divide it into six? [Juan draws two parallel vertical lines on the circle and then one horizontal line] Okay, is that an equal division? [no wait time/no response] Would everyone get an equal size piece of pizza? [no wait time/no

response] Let's put it this way, if your brother was dividing that pizza with you, would you think that was fair, depending on which piece you got? [no wait time/no response] You want to draw another one? [no wait time/no response] What's another way we could divide it into six? [no wait time/no response] Think about how a pizza is shaped. Remember how you said, how do you cut a pizza usually?

Juan: In the shape it comes in triangles.

While the student "answers" the second question by drawing lines on the circle, six other questions are unanswered in any form. Only the final question is focused upon by the student and answered. This pattern of the teacher asking questions in a chain without wait time or response by the student was observed in all of the teachers' interactions with their students, although more extreme in some cases, as in the one above. However, these unanswered questions may have more impact upon LEP students than upon non-LEP students. Many students who have English as a second language need to translate back and forth between languages in their mind--translating questions to their primary language, formulating answers, and then retranslating back into English. While teachers may not expect students to process certain questions, LEP students may not be skilled in determining when they are expected to answer a question and get lost in the translation and answer formulation while teachers are off in a new direction in their questioning.

Furthermore, many of the questions that teachers ask in question chains are very similar to each other, varying only subtly in information, but significantly in wording. This is evident in three unanswered

questions in the chain in Example 2. The teacher asks: "Okay, is that an equal division? Would everyone get an equal size piece of pizza? Let's put it this way, if your brother was dividing that pizza with you, would you think that was fair, depending on which piece you got?" All three questions ask the student to consider the mathematical idea of equivalency. Yet, while the teacher may be trying to reduce the complexity of the question in order to scaffold the student's learning, the LEP student may not understand the subtle differences and struggle with the overload of language rather than having the opportunity to struggle with the mathematical ideas.

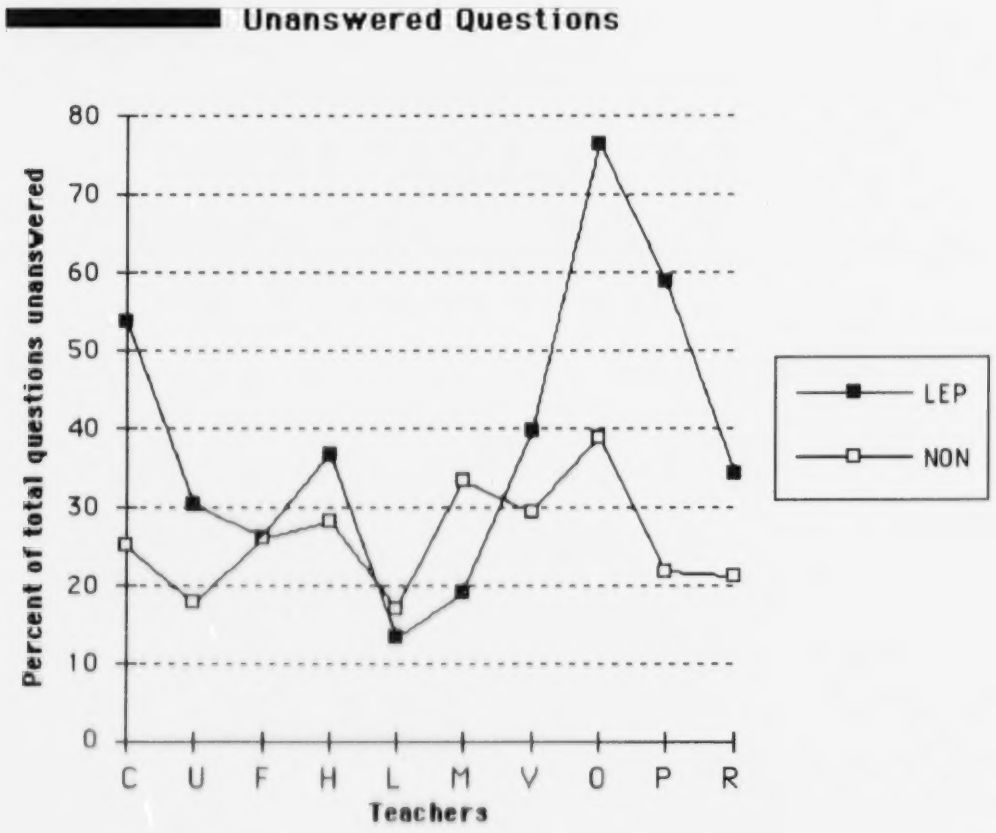
As a result of these observations I coded these question patterns and calculated the percentage of unanswered questions to total questions. The mean percentage for the ten teachers was calculated for LEP students (M = 38.93, SD = 19.246) and for non-LEP students (M = 25.875, SD =6.847). The finding supported the hypothesis that teachers asked significantly more unanswered questions of LEP students than of non-LEP students, $t(9) = 2.42$, ($p < .05$) (Figure 4).

On first glance, this pattern of unanswered questions might make sense, as LEP students, having less language, might not have been inclined to answer the questions. However, this was not the case here. In the tutoring interactions the unanswered questions were stated one after another; with less than two seconds of wait time. This implies that teachers had no intent for the student to even try to answer them. Therefore, while teachers' asked LEP students more questions overall, the effectiveness of teachers' questioning differed in terms of students' opportunity to respond.

Teacher and Student Interviews

For the second set of data I interviewed teachers and students in a stimulated recall process as they watched videotape of their tutoring session. Transcripts of these sessions were qualitatively analyzed and I

FIGURE 4



coded emergent patterns to find evidence teachers use for assessment. Throughout the analysis, differences between interaction with LEP students versus fluent students were explored.

Evidence for assessments.

This process revealed that teachers use general character descriptions as the basis for much of their assessments. For instance, in

Example 2, a teacher is thinking about when the student is comparing three eighths and one third in the tutoring situation we had just viewed on videotape ("S" is myself, the interviewer; T is the teacher):

Example 2: General character used as evidence of LEP student's understanding

S: What do you think he understood from doing that?

T: I think he got the idea that when you want equal shares. It kind of reinforced the idea of making things equal and equivalent and he could see about dividing and I could see that he thought that dividing circles was a lot harder. . . He understands what fractions are, but it's the comparison of fractions that he's not quite sure how to do, because he's not quite sure how to make the fractions so that he can manipulate them.

S: So what makes you think that about him, that he has those ideas or he doesn't?

T: I know Gerry, and I say, he's a deep thinker. He doesn't verbalize a lot. But he'll sit there and work on it and work on it and then one day it's like, "I get it".

S: A discovery.

T: Yeah. And then all the pieces have fit and I know him, he doesn't get it right away. He's a slow learner is as much as he needs a lot of repetition and he's got to attach it to something that makes sense to him. And I figure if I do enough things with him, exploring with fractions, that one of those things will make enough sense, and he'll understand what he can, how to manipulate fractions. How to divide things into fractions. It's just from working with him, I know he will do it.

The phrases "I know Gerry" and "He's a slow learner" imply that the teacher bases assessment of the situation primarily upon her general understanding of the student's character and ability rather than upon the student's specific mathematical performance or explanation.

In addition, as I analyzed transcripts of the interviews with teachers, it was apparent that teachers not only use their character assessment of individual students to interpret a situation, but their character assessment of either their class or "kids in general" as the basis for interpreting interaction with a student. For instance, in Example 3, while watching videotape of the tutoring session, the teacher answers an interview question that is directed at the mathematical understanding of the student being tutored by referring to her experience with other students.

Example 3: Teacher's generalized pronoun use when discussing LEP student

TAPE:

Teacher: Who gets more pizza?

Student: A.

INTERVIEW:

S: Do you think he understood what the instructions were?

T: I think he understood what he was doing. I think that the first impulse when **they** see things like that is that **they** see fewer people and **they** see more pizza. So I think the first impulse is "Oh, it's only two people to share the pizza, so they must be getting more pizza." Besides, I think that in any kind of new situation **kids** tend to do that, **they** tend to jump for a correct answer and look for validation. "Is this right? Is this the way I am supposed to be thinking." I think that as the tape goes on I

think that the first thing he sees is "Oh there's only two people here, there's three people there, therefore they're going to have to split in more ways, therefore they're going to have to get less." Besides sitting down and looking at actually about how much would each person get. **They** don't stop to think "How can I break this problem up in a way that makes sense to me." Rather **they** just go visual. "Okay, that one gets more."

This pattern of using statements about students in general--"they"-- to discuss individual interaction with a student was apparent throughout all teachers' interviews. However, they appeared to be more frequent in teachers' discussion of LEP students. Scores on pronoun usage in interviews about LEP students were compared with interviews about non-LEP students. Figure 5 shows the results from each pair of interviews. This graph vividly portrays the consistent pattern of teachers using more generalized pronouns when talking about LEP students. This pattern was significant, $t\,(9) = 4.18$, ($p < .05$). Teachers in this study used more generalizations when they discussed LEP students' mathematical understanding than when they discussed non-LEP students' understanding, likely reflecting a greater lack of specific knowledge concerning their LEP students.

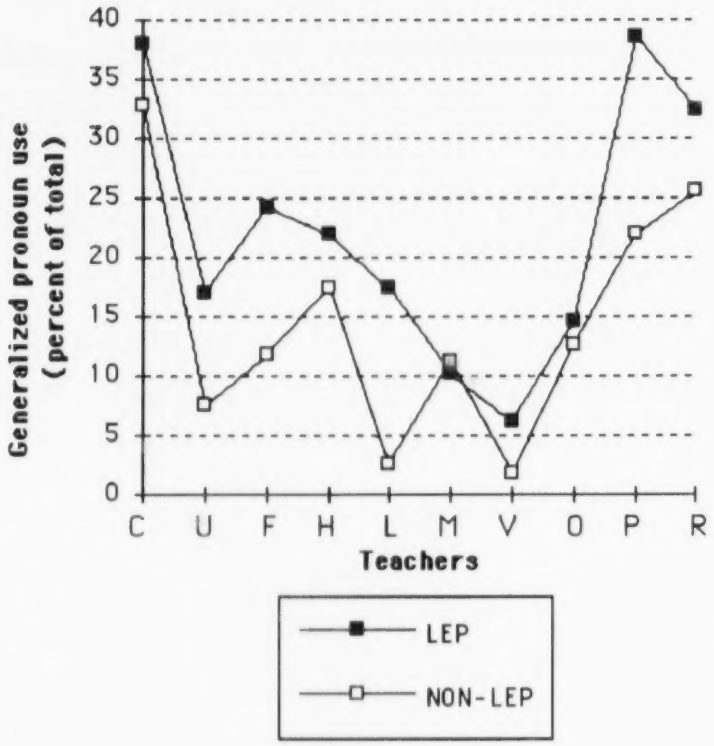
Teachers' Prediction of Students' Performance

For the third set of data I measured the accuracy of teachers' assessment of students' mathematical understanding at the whole class level by having teachers predict how well all the students in their class would perform on each problem of the Whole Class Fractions Test. Through matched pair t -tests and regression analysis I examined how teachers' prediction of students' performance compared with students'

actual performance. Overall, teachers predicted all students' success on the Whole Class Fractions Test poorly--in the low sixtieth percentile (M =

FIGURE 5

Pronoun use in teacher interviews



64.27%, SD = 5.57). Further analysis revealed that teachers generally did not predict LEP students' performance differently than non-LEP students' performance.

However, teachers significantly underestimated LEP students' performance (M_{LEP}=27.07) more than non-LEP students' performance ($M_{non\text{-}LEP}$=18.52), t (19) = 2.91, ($p < .05$). In other words, teachers believed that LEP students would get problems wrong that they actually got right

much more often than with non-LEP students. These results strengthen the implication that teachers know less about LEP students' understanding than they do about non-LEP students' understanding.

Final Summary

Triangulation of each set of data indicates that teachers' different instructional scripts created differential opportunities for teachers to assess students' mathematical understanding. Elements of teachers' instructional script are inequitable, resulting in inadequate assessment of LEP students mathematical understanding. First, analysis of the tutoring sessions indicated that while overall teachers' instructional scripts are not significantly different, important differences exist within elements of those scripts. These may impact the type and availability of information for teachers to assess regarding LEP students' mathematical understanding. LEP students spoke less elaborated sentences, thereby providing less complex verbal information for teachers to use in assessment. LEP students used manipulatives less, providing less non-verbal information for teachers to assess. Teachers asked more unanswered questions of LEP students, thereby limiting the effectiveness of their questioning and perhaps verbally overwhelming LEP students in the process.

Second, analysis of teacher interviews revealed that they used more generalized pronouns when referring to LEP students' mathematical understanding. This indicates teachers have less specific understanding of LEP students' mathematical concepts. Lastly, analysis of teachers' predictions of students' performance on the Whole Class Fraction Test revealed that teachers underestimate the performance of LEP students more than non-LEP students. Combined, these results indicated that

teachers teach LEP students differently and thus have less access to information regarding LEP students' understanding.

Discussion

Reform minded documents such as Standards implore teachers to use assessment of students' mathematical understanding to guide their instructional decisions. This research examined the impact that students' language proficiency may have upon teachers' assessment of students' mathematical understanding and instructional decision making ability. As mentioned earlier, the goal of this research is to increase teachers' effectiveness in their instruction with LEP students, by increasing teachers' awareness of issues and obstacles that they may face regarding accurate assessment of LEP students' mathematical understanding. Results from this study's three sets of data indicate that there is legitimate cause for concern regarding teachers' instructional scripts with LEP students and resulting opportunities for assessment.

Teachers do not develop a rich knowledge of LEP students' mathematical understanding. They use more general pronouns when discussing LEP students' understanding than when discussing non-LEP students and underestimate LEP students' performance more than non-LEP students. This indicates that teachers have less accurate or less specific mental models of LEP students' mathematical understanding. Why is this the case?

During informal discussions, teachers in the study generally expressed the desire to be more effective in their instruction and assessment with their LEP students and had confidence in their

implementation of SDAIE strategies. Yet, in contrast to teachers' desires, examination of discourse patterns during tutoring and interviews revealed that teachers did not accommodate LEP students' needs by varying their overall instructional scripts with LEP students. Evidence from this study shows that teachers' instructional scripts impact the quantity and quality of their knowledge of LEP students' mathematical understanding.

Teachers had less quantity of information available to them because LEP students spoke less elaborated sentences, used manipulatives less, and were subject to less effective questioning practices than non-LEP students. In addition, because LEP students spoke less elaborated sentences teachers had less quality of information available to them. This implies that teachers had less access to conceptual understanding and thoughtful reasoning by LEP students.

Short answer responses such as "yes" and "okay" imply a focus upon more factual information. This is problematic as Graesser and Person (1994) point out that students frequently answer "yes" to teachers' questions because they want to be polite, don't want to look ignorant, or don't realize their lack of understanding. Interviews with students as well as teachers in this study supported that interpretation here (Example 4).

Example 4: Teacher's reflection on her instruction

> T: "I'm not, as I look back, which is really good for me as a teacher too, I'm getting from him a nod, or I'm getting something and I'm not really checking to see if he really understands. What I'm basing my understanding, which is really kind of bad teaching, is on his nod, which, of course, he's probably going to say yes, so he doesn't embarrass himself."

When teachers use more recitative instructional scripts, the quality of information that teachers receive from LEP students' nods and short answers is questionable. However, as teachers move from recitative instructional scripts towards responsive/collaborative scripts, opportunities for teachers to assess students' understanding expand significantly as students increase their elaboration of responses and take more control of the direction of the interaction. Simultaneously, teachers' knowledge about students' understanding extends from factual to conceptual.

Furthermore, when students are generating their own understanding rather than trying to appropriate the teacher's understanding, they are less dependent on the language of the teacher. This is particularly important in the case of LEP students. Teachers, consequently, are not as dependent upon LEP students' language for assessment because as the students have more control over the problem solving process, teachers can evaluate the direction and choices of problem solving strategies that LEP students make. Moreover, when students have greater opportunities to contribute and direct the interaction, teachers consequently have greater opportunities to identify students' appropriate use of mathematical concepts and delineate students actual development from imitation.

Finally, opportunity for reflective practice through the stimulated-recall interview was valuable for teachers involved in this study. Teachers' responses indicate that watching videotape of their instruction may be an effective means for addressing the anomalies in their assessment and instructional practice with LEP students identified above. When teachers had opportunity to reflect on their teaching through videotape analysis they readily identified areas of weakness in their

instruction and assessment of students' mathematical understanding and spontaneously suggested ways to improve their instruction. For instance, in Example 4 above, as the teacher watched her tutoring of an LEP student, she conceded that she knew very little about the conceptual development of the student, and that she only knew that the student accompanied her for 'the ride'.

Teachers need assistance in closing gaps between how they believe they teach and assess LEP students' understanding and reality. As in the interviews with teachers in this study, simple, non-leading questions by an interviewer can inspire teachers' awareness of inadequate instruction and their spontaneous suggestions for improvement. Consequently, peer or university support may be helpful in constructively engaging teachers with videotape analysis that may confront teachers with the incongruities in their instruction with LEP students. Reflection can provide teachers with opportunity to rethink their instructional practice, strengthen their assessment and mental models of students' mathematical understanding, and overcome biases with LEP students. If we can help teachers understand what factors affect the accuracy of their assessments of LEP and non-LEP students, then they can make more effective instructional decisions.

While the focus in this research has been upon LEP students, the findings of this work have important implications for all teachers and students. As teachers become more sensitive to language and cultural effects on mathematical communication, their assessment and mental models of students understanding become more accurate and therefore, their instruction becomes more effective for all of their students.

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